Section 2.0 Industry Characterization

This section describes the coal mining industry in the arid and semiarid areas west of the 100^{th} meridian and details the environmental factors that make mining and reclamation activities in these areas different than coal mining in the rest of the United States.

2.1 Location and Production

The United States is divided into three major coal producing regions: Appalachian, Interior, and Western (Figure 2a). Mines affected by the proposed Western Alkaline Coal Mining Subcategory are within the Western Coal Region and are defined as mines that:

- Are west of the 100^{th} meridian west longitude,
- Are located in arid or semiarid areas with an average annual precipitation of 26 inches or less, and
- Produce alkaline mine drainage.

The Western Coal Region contains extensive deposits of low-sulfur coal (Figure 2a). Most of the coal mined in the Western Region is sub-bituminous, i.e., has a lower Btu content (8,3000 - 13,000) than eastern bituminous coal (>13,000). Western coal seams lie at various depths below the surface and vary in thickness from a few inches to over 70 feet (Energy Information Administration, 1995). The economic ability to mine the coal seams varies throughout the region and is dependent on coal quality, seam thickness, depth of overburden, geologic characteristics, and market factors. In areas such as the Southern Powder River Basin of Wyoming, thick coal seams and shallow overburden enable the extraction of large volumes of coal at relatively low cost. The low-sulfur content, in demand since the passage of the Clean Air Act, and the potentially low cost of extraction mean that coal resources in the Western Coal Region represent a highly competitive fuel in the power generation market. As the fuel market has changed, coal production within the Western Region has increased, now being nearly equal to the formerly dominant Appalachian Region. The United States produced 1.1 billion short tons of coal in 1997, with the Appalachian Region producing 469 million short tons, the Interior Region producing 172 million short tons, and the Western Region producing 451 million short tons (Table 2a).

Figure 2a: Coal Producing Areas (modified from USGS, 1996)

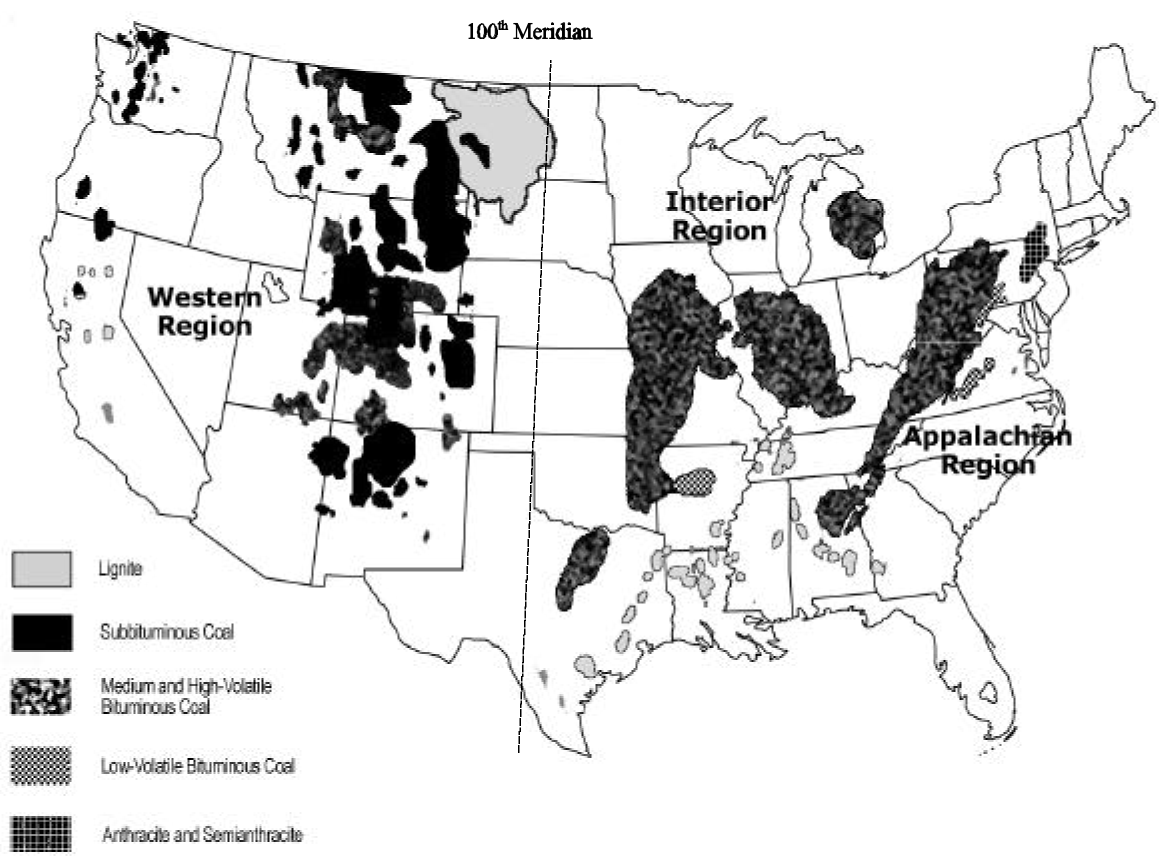

Table 2a: United States Coal Production by Region (short tons; Energy Information Administration, 1997)

	1970	**1997**[1]
Appalachian Region	427,600,000	468,778,000
Interior Region	149,900,000	171,863,000
Western Region	35,100,000	451,291,000
Total	**612,600,000**	**1,089,932,000**

[1]The total does not equal the sum of components due to independent rounding.

While domestic coal production has increased since 1970, fewer operating mines exist today, representing higher mine production. In 1997, the number of mines producing coal was less than half the number producing coal in 1988 (e.g., 3,860 mines in 1988 compared to 1,828 mines in 1997), and in the Western Region the number of mines fell from 114 to 77 in the same time period (Energy Information Administration, 1997). According to the Energy Information Administration, in 1988, the Western Region produced approximately 308 million short tons of coal, 68 percent of the 451 million short tons of coal the Western Region produced in 1997 (Energy Information Administration, 1997).

Of the 77 mines operating in the Western Region, EPA has identified 47 surface mines that potentially will be affected by the proposed Western Alkaline Coal Mining Subcategory. One of these mines, however, currently is in the final reclamation phase and most likely will be unaffected. The 47 mines produce approximately 497 million tons of coal annually, affect 192,411 acres of land, and are located in Arizona (2 mine sites), Colorado (5 mine sites), Montana (6 mine sites), New Mexico (6 mine sites), and Wyoming (28 mine sites). These sites are listed along with operation and production statistics in Table 2b.

Table 2b: Operation and Production Statistic of Potentially Affected Coal Mines in the Arid and Semiarid Coal Producing Region (modified from Western Coal Mining Work Group, 1999b).

STATE	MINING SINCE[1]	ANNUAL PRODUCTION (1,000s of tons)[2]	AVG. $/TON (STATE)[3]	YEARLY VALUE (1,000s)[4]	INDIAN LANDS	AFFECTED ACRES[5]	MINE LIFE (YEARS)	PROJECTED DISTURBANCE (ACRES)
AZ	Jan-70	4,634	$ 25.17	$ 116,638	Navajo & Hopi	6,255	6	7,236
AZ	May-74	7,090	$ 25.17	$ 178,455	Navajo & Hopi	13,604	12	16,351
CO	Feb-77	5,544	$ 18.46	$ 102,342	No	2,782	16	3,810
CO	Pending	0	$ 25.00	-	No	0	15	1,161
CO	-	-	$ 18.46	-	No	-	-	-
CO	Jan-64	1,350	$ 18.46	$ 24,921	No	-	-	-
CO	Jan-77	2,002	$ 18.46	$ 36,957	No	5,116	16	6,300
MT	Jul-94	7,051	$ 9.84	$ 69,382	No	-	-	-
MT	Jan-69	4,335	$ 9.84	$ 42,656	No	3,437	6	500
MT	Feb-71	117,000	$ 9.84	1,151,280	No	6,093	28	8,579
MT	Jan-68	9,146	$ 9.84	$ 89,997	No	-	-	-
MT	Oct-58	330	$10.10	$ 3,333	No	430	20	875
MT	Dec-80	9,015	$ 9.84	$ 88,708	No	2,251	17	4,485
NM	Aug-86	2,375	$ 21.83	$ 51,846	No	1,799	18	2,085
NM	Jan-84	4,900	$ 21.83	$ 106,967	No	3,800	30	11,300
NM	Jan-64	6,607	$ 21.83	$ 144,231	Navajo	13,000	12	4,546
NM	Jan-63	8,200	$ 26.00	$ 213,200	Navajo	7,188	18	11,000
NM	Jan-73	4,072	$ 21.83	$ 88,892	No	4,969	18	6,216
NM	Feb-89	1,259		$ 27,484	No	-	-	-
WY	Jan-83	13,559	$ 6.00	$ 81,354	No	3,059	18	5,172
WY	-	0	n.a.	-	No	249	-	-
WY	Nov-72	22,800	$ 6.00	$ 136,800	No	11,621	-	-
WY	-	80	$ 6.00	$ 480	No	1,969	-	-
WY	-	1,857	$ 6.00	$ 11,142	No	14,860	-	-
WY	Aug-76	50,000	$ 6.00	$ 300,000	No	13,017	24	12,172
WY	Jan-81	18,000	$ 4.00	$ 72,000	No	3,789	-	-

STATE	MINING SINCE[1]	ANNUAL PRODUCTION (1,000s of tons)[2]	AVG. $/TON (STATE)[3]	YEARLY VALUE (1,000s)[4]	INDIAN LANDS	AFFECTED ACRES[5]	MINE LIFE (YEARS)	PROJECTED DISTURBANCE (ACRES)
WY	Jan-78	19,946	$ 6.00	$ 119,676	No	9,686	-	-
WY	Nov-82	14,681	$ 6.00	$ 88,086	No	2,374	14	6,631
WY	-	5,805	$ 6.00	$ 34,830	No	8,310	-	-
WY	Dec-76	13,324	$ 6.00	$ 79,944	No	4,576	14	7,275
WY	Oct-58	4,200	$ 9.00	$ 37,800	No	4,590	9	2,000
WY	-	2,986	$ 6.00	$ 17,916	No	3,124	-	-
WY	Jan-78	17,921	$ 6.00	$ 107,526	No	5,706	-	-
WY	Mar-97[6]	1,005	$ 6.00	$ 6,030	No	145	28	1,886
WY	Aug-76	27,113	$ 6.00	$ 162,678	No	5,624	15	8,207
WY	May-73	6,231	$ 6.00	$ 37,386	No	7,792	25	10,429
WY	Jan-50	4,402	$ 6.00	$ 26,412	No	10,622	26	4,960
WY	Jan-74	600	$ 6.00	$ 3,600	No	5,551	12	5,765
WY	Jan-83	34,965	$ 6.00	$ 209,790	No	2,687	-	-
WY	Sep-89	5,000	$ 6.00	$ 30,000	No	4,016	-	-
WY	Nov-77	10,706	$ 6.00	$ 64,236	No	8,316	-	-
WY	Nov-85	26,640	$ 6.00	$ 159,840	No	7,041	-	-
WY	-	-	$ 6.00	-	No	-	-	-
WY	Jan-73	500	$ 6.00	$ 3,000	No	3,523	12	3,576
WY	Oct-76	769	$ 6.00	$ 4,614	No	1,011	-	-
WY	-	-	$ 6.00	-	No	-	-	-
WY	Jan-22	3,242	$ 6.00	$ 19,452	No	959	32	2,129
Total	-	496,608	$ -	$ 4,235,243	-	192,411	-	141,521

[1]Month and year from DOE database.
[2]1997 or 1996 reported total annual production obtained from either the Keystone Manual (cite) or the Department of Energy Web site (cite).
[3]The average value of a ton of coal sold by all reporting mines in the state in which the mine is located. Where state values are unavailable, the Western Region average value was used.
[4]The Annual Production figure multiplied by the average price/ton.
[5]The total number of all acres disturbed to date by the mining operation. Acres disturbed for the extraction of coal are contemporaneously reclaimed (i.e., within four spoil ridges or 180 days whichever comes first), unless a variance is approved by the regulatory authority.
[6]The date of last permit transfer. Mining commenced prior to this date.

2.2 Environmental Conditions

Coal mining operations potentially affected by the proposed Western Alkaline Coal Mining Subcategory operate under environmental conditions that are noticeably different from those in other regions of the United States. Background surface conditions are defined in this environment by the direct response of the geologic and soil-forming environment to the arid climate. Climatic, geologic, soil-forming, and topographic factors directly influence distribution and composition of vegetation in the arid and semiarid west. Western arid and semiarid areas are naturally unstable with highly eroded landscapes that are created by flash flooding which transports large volumes of sediment. Water resources are severely limited and highly valued. Common conditions occurring throughout the arid and semiarid western coal-bearing region are summarized categorically below.

2.2.1 Temperature

Temperatures in the arid and semiarid western United States fluctuate over wide daily and seasonal ranges. A daily range of 30°F to 50°F (-1°C to 10°C) is common, while the seasonal temperature ranges from -40°F to 115°F (-40°C to 46°C). Large diurnal fluctuations contribute to the physical weathering of surface materials, which increases the amount of small sediment particles available for transport by runoff generated during significant storm events. Intense wind storms generated by frontal weather systems and regional weather patterns in this region also can transport substantial amounts of sediment.

2.2.2 Precipitation

Arid and semiarid locations average 26 inches or less of annual precipitation, with roughly equal parts occurring as snowfall and rainfall. Average annual precipitation received in western states containing arid and semiarid areas is presented in Table 2c.

Table 2c: Average Annual Precipitation (inches) in Arid and Semiarid Coal States
(from National Oceanic and Atmospheric Administration, 1998)

State	Long-Term Average Annual Precipitation (inches) 1899 - 1998
Arizona	12.77
Colorado	15.90
Montana	15.36
New Mexico	13.45
Wyoming	13.16

Much of the rainfall in the arid and semiarid western United States is received during localized, high-intensity, short-duration thunderstorms, and research has indicated that relatively few storms may produce the greatest amount of erosion (Peterson, 1995). Western precipitation storms producing runoff are typically:

- Cellular in nature - localized intensity and relatively limited in areal extent;
- Of short duration; and
- Characterized by large raindrops with high kinetic energy.

Studies of precipitation typically received in arid areas indicate that the dominant precipitation events that produce runoff generally have between 1-hour and 3-hour duration peaks. For arid lands, up to 80 percent of the total 24-hour rainfall occurs within 3-hours (Hromadka, 1996). These storm events result in short-duration, sediment-rich flash flood runoff. Hjemfelt (1986) reported that only three to four percent of storm events accounted for 50 percent of long term sediment yields.

Evapotranspiration normally exceeds precipitation since solar energy is high in western arid and semiarid areas and humidity is characteristically very low. Water infiltration and retention in the soil is frequently limited, creating a net negative water balance. The negative water balance results in severe soil moisture deficits, extremely limited surface water resources, and poor plant growth and cover.

2.2.3 Erosion Prone Soils

Soils in arid and semiarid areas tend to be prone to erosion and weathering. On steep slopes, soil-forming materials frequently erode faster than they are formed. Where erosion rates are lower and soil is capable of forming, the soil typically is poorly developed with low organic matter and plant nutrient content. Soil moisture contents are characteristically low because of limited precipitation, low soil infiltration rates, and nominal amounts of organic matter.

A source of erosion is the energy created by "raindrop splash." Raindrops contain enough energy to mobilize sediment and transport it down slope. In a sediment rich environment, overland flow reaches its suspended solids carrying capacity after a short distance or period of time. When overland flow reaches dynamic sediment loading equilibrium, entrained particles are dropped and new ones are picked up until the kinetic energy of the flow is changed. When overland flows decrease in velocity, such as at the base of a concave slope, kinetic energy decreases, and entrained sediments are released and deposited. Ephemeral gullies on these lands carry flow only at times of severe storm or spring snowmelt (Heede, 1975).

2.2.4 Hydrology and Sedimentation

The western region of the United States is geomorphically young and active with a weathered topography. The landscape in the arid and semiarid regions is a mixture of mountains, mesas, plains, buttes, valleys, and canyons, and the effects of active erosion, flash flooding, and other dynamic geologic processes are pervasive. Flow channels frequently contain multiple terrace levels. Instability within drainage systems is readily observed with channel head-cutting, aggradation, bank slumping and actively changing watercourses commonly occurring.

Perennial rivers are predominant in this region and most commonly originate in mountainous areas with significant snow (in areas with average annual precipitation greater than 26 inches per year) or in very large watersheds. Ephemeral drainage systems predominate in small to medium-sized headwater areas. These ephemeral drainage systems are composed primarily of dry washes and arroyos, the lower ends of such features sometimes being depicted on USGS topographic maps as intermittent streams. More often than not, drainage features thus depicted:

- Conduct ephemeral surface water flow;
- Are mainly composed of sand bed channels;
- Have channel banks of unconsolidated alluvial deposits;
- Possess a nearly unlimited source of sediment that may be transported by flash flooding; and
- Commonly contain sediment at concentrations as high as 1×10^6 mg/L during flash flood runoff events.

For an average of 11 to 11 ½ months a year the washes and arroyos are dry, normally flowing only in direct response to precipitation runoff. When rainfall does generate runoff, it is frequently characterized by high-volume, high-velocity, sediment-laden, and turbulent flows with tremendous kinetic energy that ceases soon after the precipitation event stops. For many very short-duration precipitation events, the runoff water never reaches the main-stem channels downstream. This turbulent flow pattern establishes a fluvial dynamic equilibrium in arroyos and washes that is characterized by episodic aggradation and degradation of channel morphologic characteristics. The sediment is continually transported down-stream, normally at the maximum level of concentration possible for the kinetic energy available within a given flow.

Floodplains that develop on arid landscapes are wide and unstable, as the morphology and position of the main stem channels change with every major precipitation event. The migration of the channels across the landscape redistributes the sediment, with the primary source of sediment the mass wasting of the vertical sides of the arroyo channels. In comparison to the total amount of sediment involved in erosion, transport, and deposition during runoff from a given storm event, a relatively small amount of sediment actually leaves the watershed.

2.2.5 Vegetation

The response of vegetation to the low amount of precipitation in the arid and semiarid coal regions is evident. The major vegetation zones in this western environment are desert, grass and brush lands, and open forests types (e.g., pinyon-juniper and ponderosa pine) characterized by discontinuous and sparsely distributed grasses, forbs, shrubs, and trees. Species composition varies from north to south and at various elevations. Slope, aspect, moisture retention, and solar insulation play a significant role in the distribution of plants within a given area. Most plants within the arid and semiarid precipitation zones have adapted their ability to germinate, establish, and grow to the dry conditions and cycles prevalent throughout the region. With moisture availability being the primary limiting resource to plant growth, floral adaptations and growth habits center around a variety of moisture harvesting, conservation, and retention strategies. Living ground cover is frequently sparse, although cumulative ground cover may be significant since decomposition tends to be retarded by limited moisture availability.

2.2.6 Watershed Runoff Characteristics

Ephemeral and intermittent flows in the arid and semiarid western United States are unique in their flow and duration characteristics. Runoff generated by a single storm event may last from a few minutes to hours depending upon the size and characteristics of the affected watershed. Typically, flows last a few hours and, except for a high-water debris line, any evidence of their passage is gone within 48 hours or less. Frequently, flows run above ground for short to moderate distances, and gradually dissipate into the beds of the dry washes and arroyos they have followed or created.

While storms in this region typically drop less precipitation than their eastern counterparts, the intensity is often greater, and the amount of runoff generated is normally equal to or greater than that created by an eastern precipitation event of equivalent size. The increased runoff occurs because the poorly developed soil and sparse vegetation of western areas have a greatly reduced capacity to capture and harvest precipitation. The water that collects and drains from western precipitation events is nominally impeded and runoff characteristically takes the form of turbulent, high-velocity, flash floods. Rising stages often start initially as a trickle of water, followed by a wall of water roaring through the channel a few minutes later. Multiple crests may occur as subwatershed runoff is delivered to a main channel. As the flow recedes, velocity and volume fall off rapidly and trickle to an end over a period of a few hours.

Sediment concentration in these turbulent flows normally has a direct relationship to their kinetic energy. Sediment is in abundance within the channels where flow occurs and occurs at concentration levels near or at flow carrying capacity. Sediment concentration frequently varies over a wide range of concentration levels during a given flow event. Sediment content from a few thousand to 500,000 mg/L may be expected with values in the 25,000 to 150,000 mg/L range being common. The variation occurs primarily with changes in flow volume and velocity, although rising and falling stages may exhibit differing sediment concentrations at similar stage heights.

2.2.7 Cumulative Effect

The cumulative effect of the geologic, hydrologic, and climatic conditions unique to this arid and semiarid region can be summarized as follows:

- Western arid and semiarid areas are naturally geomorphically unstable;
- Landforms frequently exhibit dynamic geomorphologic and erosion processes;
- There is virtually an unlimited supply of sediment available within the arroyos and washes;
- Large volumes of sediment are normally transported by short duration, flooding, and turbulent flows;

- Particle erosion from a rough steep topography contributes dramatically to the natural generation of sediment;
- The runoff pattern predominating in ephemeral watersheds is flash flooding; and
- The sediment yield in tons per acre per year from these lands is significantly higher than from similarly undisturbed vegetation covered lands of the mid-western and eastern United States.

Although water is sparse, the amount of water that physically runs off is significant due to the nature of the soils and the lack of effective surface cover. It is this runoff that has created the highly-eroded landscape and variable topography that is prevalent throughout this region. Environmental conditions limit surface and shallow subsurface water resources and the distribution and development of aquatic and riparian biologic resources. Direct use of surface-water runoff by man and wildlife also is limited due to its sporadic availability and poor physical quality. The limited surface-water resources that do occur within the region have high habitat and use values. Infiltration of surface runoff to local water tables provides limited, but valuable, useable ground-water resources.